DOCUMENT RESUME

ED 222 685 CE 034 060

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TITLE Utilization of Alcohol Fuel in Spark Ignition and Diesel Engines.
INSTITUTION Minnesota Curriculum Services Center, White Bear Lake.
SPONS AGENCY Minnesota State Dept. of Education, St. Paul. Div. of Vocational and Technical Education.
PUB DATE Jul 81
NOTE 63p.; Photographs may not reproduce well. For related document, see CE 034 061.
AVAILABLE FROM Minnesota Curriculum Services Center, 3554 White Bear Avenue, White Bear Lake, MN 55110-5496 (B419C, $2.75).
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052) -- Guides - Classroom Use - Materials (For Learner) (051)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Auto Mechanics; Behavioral Objectives; Diesel Engines; *Engines; Fuels; Instructional Materials; Postsecondary Education; Seminars; Trade and Industrial Education
IDENTIFIERS *Alcohol Fuels; Carburetors; *Engine Modification; Ethanol; Ignition Systems

ABSTRACT

These five units comprise a course intended to prepare and train students to conduct alcohol fuel utilization seminars in spark ignition and diesel engines. Introductory materials include objectives and a list of instructor requirements. The first four units cover these topics: ethanol as an alternative fuel (technical and economic advantages, properties of ethanol and gasoline), engine coversions (three main methods of utilizing alcohol in a spark ignition engine), engine conversion through carburetor modifications and ignition timing adjustments, and alcohol fuel in a diesel engine (six stages of diesel combustion, diesel and alcohol test results). Unit 5 lists references and available additional information and provides a glossary of alcohol-related and automotive terms. (YLB)

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UTILIZATION OF ALCOHOL FUEL IN SPARK IGNITION AND DIESEL ENGINES

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INTRODUCTION

The information herein indicates the findings of many individuals who have involved themselves in the expermentation of Ethanol as an alternate fuel for the "spark ignition and the "diesel" engines.

The test procedure and results found in this text will serve as direction to conduct additional tests and experiments. Other information found in the text can be used as background material to develop a foundation in the utilization of Ethanol as an alternate fuel.

MAJOR GOAL

The goal of this course is to prepare and train students to offer, instruct, and conduct alcohol fuel utilization seminars in Spark Ignition and Diesel Engines.

The objectives for SPARK IGNITION ENGINES:

1. The student will be given information concerning alcohol as an alternate fuel

2. The student will receive information so that he/she will understand the similarities and differences of alcohol and a petroleum fuel for a spark ignition engine

3. The student will also have the opportunity to review carburetion principles and learn how to make the necessary changes to modify a carburetor and make the necessary tests with alcohol as an alternate fuel

DIESEL ENGINES:

1. The student will receive information on the theory of combustion in a diesel engine

2. The student will receive information to appreciate the fuel particles search and need for oxygen

3. The student will receive information concerning the ignition qualities of alcohol in a compression ignition engine

4. The student will have the opportunity to review diesel injection pump calibration and internal timing

Broad Objectives in Setting up Alcohol Fuel Training Seminars:

INSTRUCTOR REQUIREMENTS:

1. Instructor should have a strong background in automobile mechanics

2. Instructor must have a thorough understanding of carburetion and ignition in relation to combustion of a spark ignition engine

3. Instructor must have a good working knowledge of carburetors and emission control systems used on automobile engines

4. Instructor must have a thorough understanding of the self ignition characteristics of the diesel engine

5. Instructor must have a basic knowledge of injection pump characteristics, calibration and internal timing principles

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UNIT I

TOPIC A: History of Alcohol as Motor Fuel

The first serious attempt to examine the possibility of alcohol as a fuel in competition with petroleum seems to have been made in 1894 at Leipzig, Germany, by Professor Hartman for the Deutschen Landwirtschafts-Gessellschaft. German alcohol distillers, seeking to enlarge their market, succeeded in interesting the German Government. They pointed at the significance of having available a source of fuel for power, production within the nation from yearly crops, while the supply of crude oil may ultimately become exhausted.

By Acts of U.S. Congress for June 7, 1906, and March 2, 1907, denatured ethanol became exempt from internal revenue taxation when used in the industries. The U.S. Department of Agriculture in 1907 published Farmer's Bulletin No. 277, "The Use of Alcohol and Gasoline in Farm Engines", by Charles Edward Lucke and S.M. Woodward.

In 1909 the United States Geological Survey published a bulletin, No. 392, called "Commercial Deductions from Comparisons of Gasoline and Alcohol Tests on Internal Combustion Engines". This thirty-eight page bulletin by Robert M. Strong is the result of careful observation of 2,000 tests conducted at St. Louis, MO, and Norfolk, Virginia. The tests were under technical supervision of R.H. Fernald, engineer in charge of the producer-gas section of the technologic branch.

TOPIC B: Technical Advantages of Alcohol Fuel

The alcohol engine gives equal fuel consumption to that of a gasoline engine, with a substantial bonus of greater power from the same size of engine. Advantages are available by using a smaller engine. (21). This would be of considerable importance as the car manufacturers continue to down size for gasoline engine economy.

Combustion of alcohol is more likely to be complete due to a wider range of fuel-air ratios which results in an explosion (18).

The burning of alcohol forms no soot or carbon in the engine (16). No black smoke is produced from an alcohol engine operating under heavy loads (2).

Small alcohol fires can be extinguished using water (2). Because alcohol contains no light fractions it is less of a fire hazard than gasoline but more caution is needed with the vapors existing in a storage tank. With alcohol in the tank the vapor-like mixture over the fuel is probably explosive while in the case of gasoline the mixture of fuel and air is too rich to be a danger (1). As this seems to be the only disadvantage, it is not listed separately (21).

Unlike gasoline, alcohol is a pure chemical which does not degrade in storage (21).

The maximum flame temperature using alcohol fuel can be 107°C, lower than what is common with gasoline (3). This makes it possible to design large two stroke cycle alcohol engines (21).

Alcohol fuel will not burn valves or destroy exhaust ports, there is less tendency to burn lubricating oil, a smaller cooling system can be used (2), and supercharging of the engine is easier to accomplish.

When operating in hot weather, water can be added to alcohol fuel for extra cooling effect (21).

Moisture in alcohol fuel adds bulk to the flow of combustion products to operate gas turbine engines very efficiently (21).

Alcohol's resistance to evaporation becomes an advantage in tropical countries to avoid vapor lock of the fuel system (21).

Alcohol combustion is slower than that of gasoline and therefore the engine runs more quietly (21).

Ethanol is a very pleasant fuel to handle. It has no unpleasant odor and is relatively safe for minor skin contact (21).

TOPIC C: Economic Advantages of Alcohol Fuel

Alcohol is solar energy in liquid form. Only man-made laws restrict its abundance (21).

To assume that fuel quality alcohol would be made by the same equipment and process presently used for beverage alcohol is an error. It is possible to use low cost steel components where presently glass, copper and stainless steel are needed. To save energy, radiation might be used to sterilize the mash before fermentation. A distillery has never been designed with low capital investment, fuel quality alcohol, and evergy conservation as the primary objectives. Taste, the inclusion of other alcohols and poisonous chemicals are not important for fuel quality alcohol. High fuel oil content in alcohol fuel is in fact an advantage to aid lubrication of the engine. Thus the cost of alcohol fuel and the cost of an alcohol fuel plant is yet to be determined (21).

Ethanol contains only two thirds as much energy per liter as does gasoline. Methanol or wood alcohol contains half the energy of gasoline. Surprisingly, several very reputable research authorities then assume that to do the same work one would need twice as much fuel (1). That fails to consider that alcohol engines are twice as efficient as gasoline engines in using the energy of the fuel (21).

The yield of energy per hectare of farm crops can be at least twice as high as the annual yield from forest products. Factories to produce wood alcohol must be relatively large and require much more capital than an agricultural alcohol unit. None the less, the building of sufficient wood alcohol plants to make Canada completely self-sufficient for motor fuel on wood alcohol alone, has been estimated to cost half as much as the development of the Canadian tar sands (19).

When engines replaced the horse it took great demands for feed and forage from farm markets as well as the substantial income farmers enjoyed from the production and sale of draft animals for mines, forestry and construction industries (6). Alcohol as motor fuel has the unique quality of having a practically unlimited potential market (21).

In the Canadian climate, sugar beets, potatoes, and Jerusalem artichoke, produce the highest yields of alcohol per hectare. Annual yields of 30 hectoliters of ethanol per hectare are not difficult to achieve with any of the three alcohol crops (20). Beet tops and the pulp from the distillation process are excellent livestock feeds. Nothing is wasted (21).

It may be true that alcohol production costs will not allow as much direct taxation by governments as has been convenient with gasoline. However, the new jobs created and the improvement in balance of trade is likely to generate so much prosperity that increased income tax revenue, corporation taxes, and sales tax revenue would more than compensate for losses in gasoline tax (21).

Agricultural alcohol production has the potential to provide jobs, train farmers, and develop new land. The large buildup of farmers and farm equipment is then ready at a moments notice to produce food instead of fuel. We stand and look at a hungry world and yet in North America we cannot encourage people to farm. Existing farmers suffer economic restraint because of surplus production (21).

TOPIC D: Advantages of Alcohol As Motor Fuel

Any gasoline engine can be modified to run on alcohol by elimination of plastic parts, changing the carburetor and supplying a lot of heat to the carburetion and intake system, but to benefit fully from the advantages of alcohol as motor fuel the engine must be specifically designed for that purpose.

The alcohol engine gives equal fuel consumption with that of a gasoline engine with a substantial bonus of greater power from the same size of engine. Advantages are available by using a smaller engine. This has particular application in aircraft as well as giving fuel economy to automobiles.

Neat alcohol burns very cool. Since nitrogen oxides emitted by internal combustion engines originate from air being heated in the combustion chambers, a lower temperature of combustion will result in much lower levels of pollution without the necessity of any special devices. Alcohol engines are good for our environment.

The cool burning property of alcohol eliminates the possibility of burning valves and opens up the possibility of designing large two stroke cycle engines.

Alcohol burns well with as much as 20% water added. The water adds bulk and cooling to operate gas turbine type engines very efficiently.

The cooling properties of alcohol also make it attractive to use supercharging of piston-type engines. Alcohol does not evaporate as easily as gasoline. This becomes an advantage in tropical countries to avoid vapor lock of the fuel system. Unlike gasoline, alcohol is a pure chemical and does not degrade in storage (22).

TOPIC E: Is Alcohol Corrosive?

Motor fuel consumption in Canada is about 36 billion liters per year (10). Gasoline used by automobiles in the United States in 1973 was 375 billion liters (11). The flow of money which this represents is likely to cause some distortion of information which is made available.

American Petroleum Institute in their technical assessment of alcohols as motor fuel have used wording which leaves the impression that alcohols are seriously corrosive to metals normally used in an automotive fuel system (1). In fact, alcohol is dangerously corrosive only under very specific conditions which can easily be avoided.

When ethanol burns with insufficient supply of air, acetic acid is formed (vinegar) which promotes corrosion in the engine. This can be prevented by addition of benzol or acetylene to the ethanol (12). Sometimes a little ammonia is added to the alcohol to avoid corrosive exhaust gases (13).

Methanol has been used in racing engines giving a strong smell and causing watering of eyes. That results from the rich fuel-air ratio used in racing. When methanol burns with limited air supply, formalin and traces of formic acid are formed (21).

General Motor's technical staff indicated in 1977 that there is no problem of corrosion using pure methanol (15).

In practice, there is no reason to use a rich fuel-air ratio in the alcohol engine. Burning a lean mixture results in an exhaust which is very clean and odorless; the products of combustion being little more than carbon dioxide and water. With proper manipulation, there seems to be no undue corrosion of the interior of an engine due to use of alcohol (16).

Denaturants which are added to ethanol to make it unfit to drink might also make it unfit to use in an engine. Methanol can be used as a denaturant without harming the use of ethanol as motor fuel. In some countries, the denaturants used are very corrosive to engine parts (17).

TOPIC F: Alcohol Safer and Cleaner

Small alcohol fires can be extinguished using water and alcohol fires don't start as easily as gasoline. Alcohol combustion is slower than gasoline and less noisy. Combustion of alcohol is more likely to be complete due to a wider range of fuel-air ratios which results in an explosion, the exhaust is practically odorless consisting mostly of water vapor and carbon dioxide.

The burning of alcohol forms no soot or carbon. Carbon-build-up in an engine is eliminated. Pure alcohol burned in a lean mixture causes no undue corrosion in the interior of the engine.

The cool exhaust temperature of an alcohol engine results in less tendency to burn lubricating oil. Less cooling water and a smaller cooling system are needed to operate the alcohol engine.

There is no black smoke produced from an alcohol engine operating under heavy loads.

It seems reasonable to expect that the price of denatured alcohol will eventually become as low as or lower than the price of gasoline (22).

UNIT I TOPIC G

PROPERTIES OF GASOLINE AND ETHANOL

	GASOLINE	ETHANOL
Chemical Formula	Complex	C_2H_5OH (CH_3CH_2OH)
Molecular Weight	Complex	46.07
Carbon to Hydrogen Weight Ratio	5.25:1	4.00:1
Carbon, % by weight	84.00	52.14
Hydrogen, % by weight	16.00	13.12
Oxygen, % by weight	0	34.74
Boiling Point, °F at 1 atmosphere	90 - 410	173.3 (78.5°C)
Freezing Point, °F at 1 atmosphere	-65 to -161	-174.6 (-117.3°C)
Vapor Pressure, PSI at 100°F and 1 atmosphere	9.0 to 12.5	2.5
Latent Heat of Vaporization, Btu/lb. at boiling point and 1 atmosphere	141.00	378.13
Latent Heat of Vaporization Btu/lb. at 77°F and 1 atmosphere	147.30	395.00
Heat of Combustion (Heating Value) at 77°F.		
Lower Heating Value, Btu/lb.	19,000	11,550
Lower Heating Value, Btu/gal.	110,960	76,230
Weight per Gallon, lb.	5.84	6.60
Specific Gravity at 60°F	0.745	0.794
Flash Point	-45°F	56°F
Optimum Air/Fuel Ratio	15:1	9:1
Tolerable Air/Fuel Ratios Rich to Lean	13.2:1 to 71.4:1	5.3:1 to 23.3:1
Octane Number, Research	90	106
Maximum Desirable Compression Ratio, spark-ignition internal combustion engine	8.5:1	14:1
Energy of Optimum Fuel/Air Mixture, Btu/cu. ft.	94.8	94.7

The figures given here are representative of an average premium automotive gasoline sample, due to the fact gasoline is a blend of octane and several hydrocarbons.

TOPIC A: Conversion of a Spark Ignition Engine - By Don Berndt, CAVTI

The conventional automobile engine design, as we know it, was never intended to burn alcohol as its main fuel. Various percentages of alcohol have been mixed with gasoline and the engine will perform very well. However, to expect the average passenger car or light truck to run on 100% alcohol, one must take into consideration the high latent heat of vaporization of alcohol, which generally speaking, will not perform through the gasoline carburetor without some modifications being made to the carburetor and adjusting the ignition timing. These are minor changes and will permit the engine to perform quite satisfactorily in temperatures above 30 F. You will then realize that the engine performs better as the engine temperature and the ambient temperature rises. It has been found that if the intake air temperature can be maintained at 200 F. or above, it will allow excellent driving performance.

With temperatures in mind, one can achieve satisfactory starting in rather cold weather. To accomplish this, a pre-start heater would be necessary for total engine warm up, as is the practice in our Minnesota weather for the gasoline engine. As I indicated, 200 F. intake air temperature is desireable for operation. It will be necessary to heat the intake air to around 100 F. for starting on straight alcohol.

Another method to overcome the cold start problem is to install a small auxiliary gasoline tank equipped with a small manually operated pump to inject gasoline into the carburetor air norm, similar to accelerator nozzle. Thus hand feed the engine at the initial starting and very early warm-up, or until the exhaust manifolds could begin to produce heated intake air.

This type of conversion is one that can be made to run on alcohol in the warmer seasons or while operating the engine in an area where the supply of alcohol is plentiful. It can be easily converted back to operate on gasoline as extreme cold weather and driving habits may dictate or in the event of travel out of the range of the alcohol supply.

TOPIC B: Modification Procedures - By Don Berndt, CAVTI

Specifications of Engine Used For Alcohol Fuel Testing:

1973 Ford 351 CID
Bore and Stroke 4.00 x 3.50
Compression Ratio 8.0 : 1
2 Barrel Autolite Carburetor
Standard Breaker Point Ignition

Engine load was controlled during all the tests with a "Go Power" engine dynomometer.

This engine was first used to experiement with various fuel mixtures of gasoline and alcohol in 1978. At this time, the engine was carefully tuned to manufactures specifications and base tests using 100% regular leaded gasoline was made which several gasohol tests were matched against. Such as 90 - 10, 80 - 20, 70 - 30, and 60 - 40.

In the Fall of 1979, it was decided that this engine should be modified to run on 100% alcohol. Thus it was re-checked against manufactures specifications and more tests of 100% regular leaded gasoline were made to establish a reasonable base on which to match the forthcoming alcohol fuel tests. Then one modification change after another was made, each time a test run on the dyno was made to determine the result. We wanted to hold the extent of the modifications to the carburetor and the distributor, thus allowing a comparatively simple conversion and one of minimal cost to the automobile owner. The questions was, "Could acceptable results be obtained on an 8.0 : 1 compression engine?" The answer certainly seems to be yes and I might add, that the results are far above my personal expectations.

Performance in all of the speed and load ranges show outstanding results on the dynomometer. A 9.3% horsepower increase at 1500 RPM (wide open throttle and full load). With additional tests at 500 RPM intervals and progressively lighter loads up to 3500 RPM resulted in an average of 9.12% more horsepower for all tested speed ranges.

Cold engine starts at shop temperatures (60°F.) were excellent after the changes were made to modify the carburetor and only initial ignition timing was changed. No other ignition changes were made. Although Minnesota winter temperature starts do promise to be a challenge, to say the least.

TOPIC C: Test Results - Fuel Economy Comparison Tests of Alcohol vs Gasoline, by Don Berndt

The vehicle used was a 1977 Ford LTD II equipped with a standard 351 CID Cleveland engine, 2 barrel Ford carburetor and the usual other equipment, factory air, power steering and automatic transmission.

The weather condition was a raw Minnesota February day of 20 F., with a 15 to 20 mph wind out of the south west. The tests were all run within a two hour block of time, on a north - south highway. They were made at a steady 50 mph, 55 mph and 60 mph, using a 1/10 th. of a gallon mileage tester. A series of tests of the above mentioned speeds were done going against the wind and then turning around and making the same tests again on the return trip over the same terrain going with the wind.

The carburetor was then changed to a modified Ford 2 barrel version, along with the timing modification and an auxillary tank with 190 proof ethanol placed on the rear floor of the vehicle. Again the same road and speeds were used to establish an economy test. An average manifold vacuum reading was taken as well as engine RPM for each test with gasoline and with alcohol, which were used later back in the shop on another 351 Cleveland Ford engine.

The following chart shows the results of both economy tests for gasoline and alcohol. Notice how manifold vacuum would rise as the miles per gallon rose.

TEST #	MPH	RPM	MPG	VACUUM	FUEL	TEMP.
1	60	2200	12	12	gas	20° F. Ambient temp. with a wind up to -10°F.
2	55	2000	12	11	gas	
3	50	1800	14	12	gas	
4	50	1800	21	17	gas	
5	55	2000	22.5	16	gas	Overall average MPG gasoline 17.08 MPG. Overall average MPG alcohol 10.33 MPG.
6	60	2200	21.5	17	gas	
1	60	2200	6	6	Alcohol	
2	55	2000	8	8	Alcohol	
3	50	1800	9	10	Alcohol	
4	50	1800	14	16	Alcohol	
5	55	2000	12.5	16	Alcohol	
6	60	2200	12.5	16	Alcohol	

The engine RPM and vacuum reading which were recorded on the gasoline test runs were now used with the original carburetor from the 77 LTD II, which was installed on the 351 Ford engine back in the shop and run with the dynomometer, thus controlling engine RPM or throttle opening at the RPM that corresponds with the road speed (50, 55 & 60 mph).

TOPIC C, Con't.

Using the dynomometer load control to control manifold vacuum, it was then possible to realize the actual load the engine felt on the road test. At this time a torque reading could be read on the dynomometer, which after running several tests at a given engine speed (MPH) for close verification, the modified carburetor was once more put back on the dyno engine and tests with alcohol were made to match against the gasoline tests.

Now the important point to remember here is the ambient temperature on the road test and now in the shop. Of course one variable these tests had no control of was the fact that two individual engines were used, even though both engines were in excellent condition.

TEST #	RPM	VACUUM	TORQUE	TEMP.	FUEL
1	1800	14.5	85	65°F.	gas
2	2000	14.0	85	65°F.	gas
3	2200	14.0	90	65°F.	gas
1	1800	14.5	85	65°F.	Alcohol
2	2000	14.0	85	65°F.	Alcohol
3	2200	14.0	88	65°F.	Alcohol

Road test information as it was applied to the stationary test engine with the dynomometer using the same carburetor and engine settings as on the road test vehicle (351 Ford) that established the MPG gasoline tests with 100% gasoline. Then changing to the modified carburetor and the modified timing setting and 100% Ethanol the test runs were repeated. The results bears up the theory that the difference in ambient temperature will result in poor economy and performance as was experienced during the road test with outside temperatures at 20° F. and 15 to 20 mph Southwesterly wind and chill factor of -10° F. Operating in shop conditions with 65 F. ambient temperature, the modified carburetor and alcohol had no problem allowing engine performance to come within less than 1.0% of that of the conventional carburetor and gasoline for fuel.

Obviously the conventional gasoline fueled engine will need some help in cold climates such as a fuel and intake air heater. Otherwise, it will need internal modifications and raise the compression ratio to somewhere between 11.0:1 and 14.0:1, to make it an all weather Alcohol Spark Ignition Engine.

TOPIC D: Conversion of 2000 CC Pinto Engine, by Don Berndt

This engine is used as a power source for testing automatic transmissions and is worked quite hard, although its performance cannot be measured in horsepower as this machine is not designed to do so. The engine is required to accelerate from idle speed to 3000 to 3500 RPM under normal to moderately heavy comparative road loads and decelerate generally quite rapidly. The engine under these operating conditions seems to perform with a noticeably quicker response.

Realizing this is only a judgement measure and that it also operates in a temperature controlled environment. It is felt that it also would perform satisfactorily in mild weather in a vehicle with only exterior modifications.

The modifications were limited just to the carburetor and ignition timing. These changes would be considered basic and that the ultimate conversion being of an internal nature, thus increasing compression ratio and the use of a fuel pre-heater for extreme cold weather operation.

TOPIC E: The Alcohol Engine - By Don Berndt, CAVTI

The carbureture modification method of burning alcohol in the conventional low compression engine as explained previously, will only allow approximately two thirds the amount of fuel economy as was previously possible with gasoline on a given engine. However, if that same engine would undergo the internal modifications to increase the compression ratio to 12 or 13 to one ratio, much more can be done with a given engine in respect to all around performance, including fuel economy.

The principle upon which the diesel engine operates, using heat of compression to ignite a calibrated amount of fuel into the combustion chamber, at the exact moment, will produce a fuel efficient power impulse from each cylinder; this principle, in effect, can be used to modify a spark ignition engine to be considered an alcohol engine.

By increasing the fuel efficiency and compression ratio, an increase in power and performance can be achieved in an engine, along with the use of a slightly modified carburetor. The main consideration given an engine selected for this conversion, would be in the lower area of the block; such as connecting rods, rod bearings and main bearings. A four bolt main block, as used by some gasoline fueled engines, would be best suited for this conversion.

The model of engine used will determine, to some degree, what will need to be done in the area of ignition timing. Realizing that Ethanol has an octane rating of approximately 106 octane, thus the initial timing may be adjusted initially as it was for gasoline and as the final fine tuning is developed, a new specification will be determined.

This particular conversion method will make cold weather starting considerably easier and cold driveability much better, as the advantage of the higher compression creating heat within the combustion chamber to aid fuel vaporization and ignition quality. Fuel economy can, in most engines, match its conventional gasoline counterpart.

Fuel injection is another step in the perfecting of alcohol utilization in a spark ignition high compression engine. However, with Ethenol being the dry fuel it is, there are definite areas of concern in the pump and injector systems area. However, there are possibilities of the adaption of some of the very latest computerized systems now being used in our 1980 model gasoline engine equipped vehicles.

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UNIT III

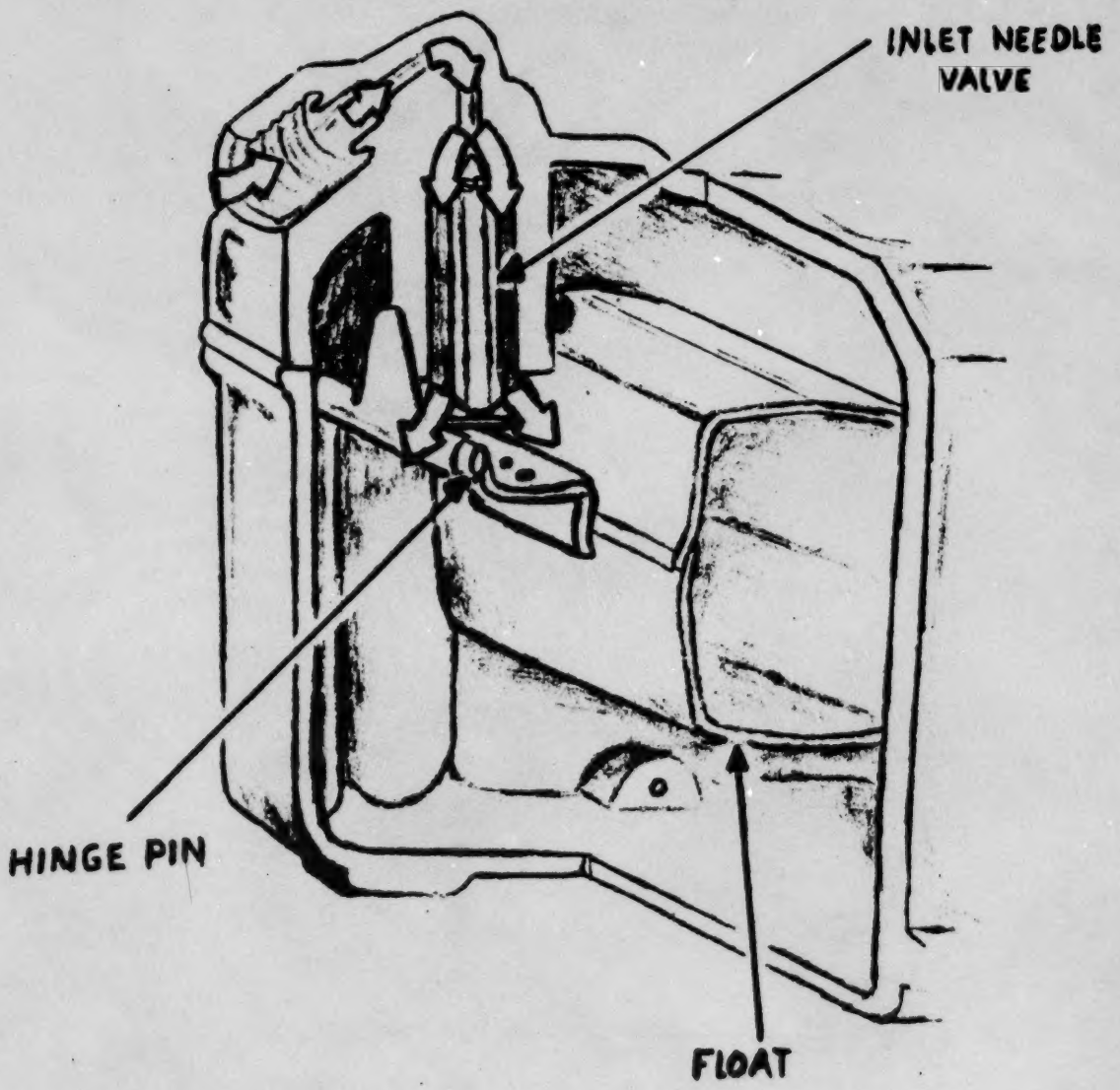
TOPIC A: Familiarization and Review of Carburetion Circuitry

A. Ford Carburetor Training Course #9502.1

Charts #9502.1-2
#9502.1-3
#9502.1-4
#9502.1-5
#9502.1-6
or the equivalent from another manufacturer

B. Option: Text books of your choice dealing with basic carburetion

FUEL INLET SYSTEM



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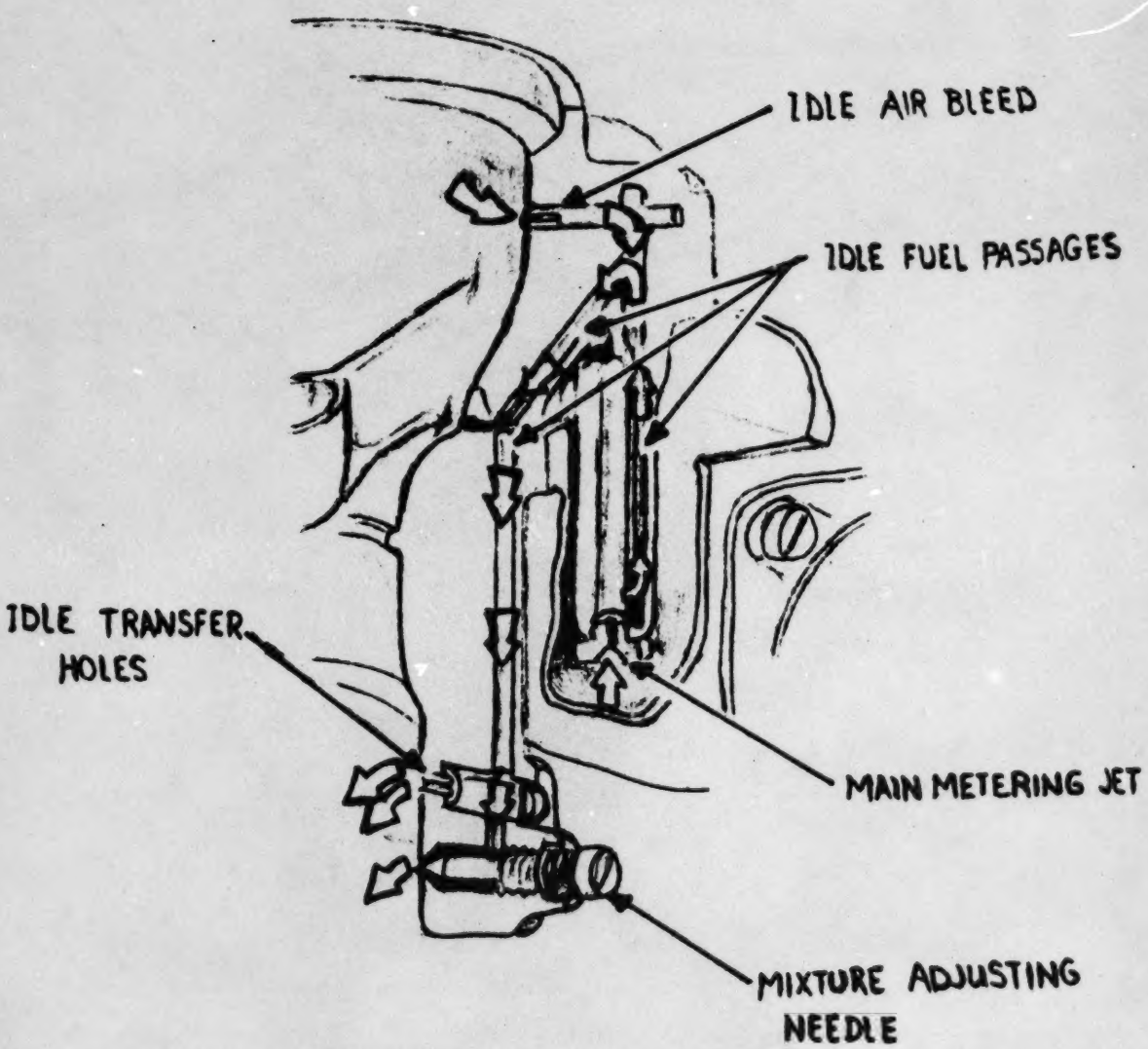
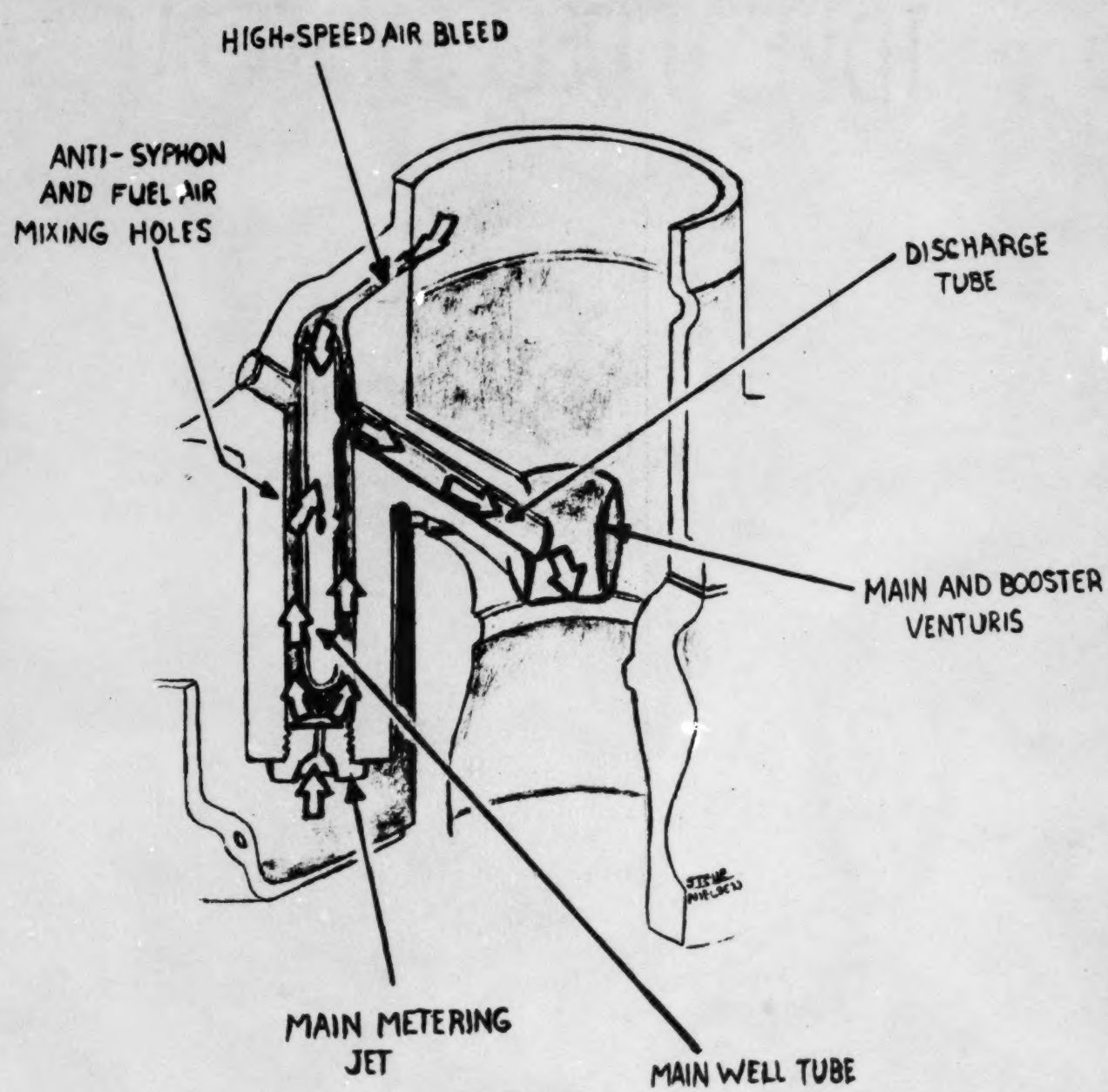
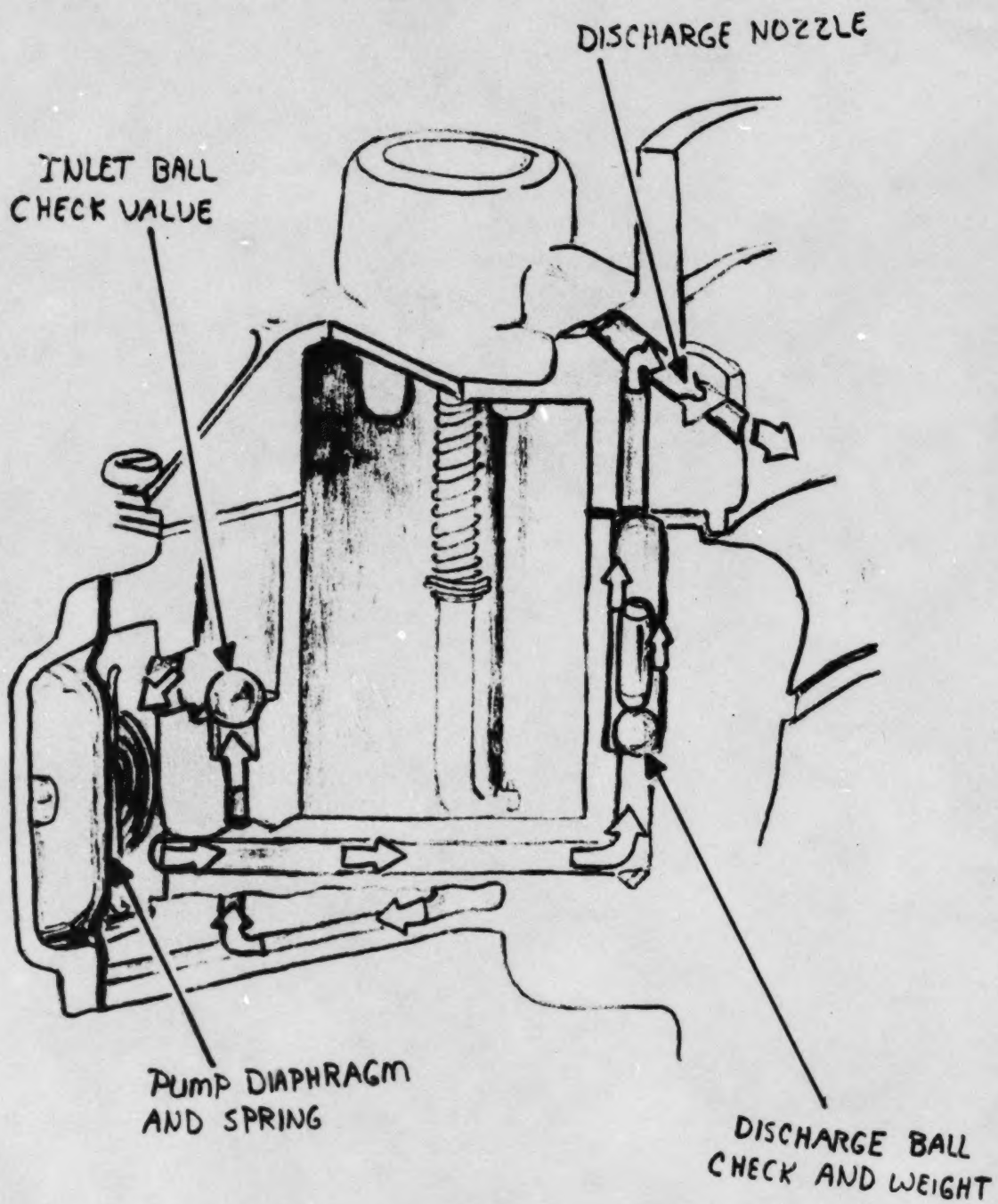
IDLE FUEL SYSTEM





MAIN METERING SYSTEM

ACCELERATOR PUMP SYSTEM



TOPIC B: Modification Procedures of Various Current Model Carburetors

How to determine the over size of a main metering jet:

1st Method: Area Method

Area of Circle -

$D^2 \times \pi (.7854)$ = Area x % of over size

EXAMPLE: I want to increase a .060 jet size by 40% on the area

$.060^2 \times .7854 =$

$.0036 \times .7854 = .0028274$ (area)

$.0028274 \times .40 = .0011309$ (amount oversize)

$.0028274 + .0011309 = .0039583$ (new area)

To find diameter of an area:

$$\frac{\text{Area}}{\pi (.7854)} = \sqrt{\quad} = D$$

$$\frac{.0039583}{.7854} = .0050398 \quad \sqrt{\quad} = .0709915$$

2nd Method: Diameter Method

EXAMPLE:

A. $.060 \times .40\% = .024$

$.060 + .024 = .084$ (much too large)

B. $.060 \times .167\% = .010$

$.060 \times .010 = .070$

NOTE: There is a considerable difference should the area be confused with diameter when figuring percentage of oversize.

The following detailed procedure may be transposed to the other carburetors and only certain cautions and strange areas will be pointed out.

Picture 1

Picture 2

Pictures 1 through 5 show a two-barrel Holley carburetor, used on 4-cylinder Ford engines. Picture 1. Remove the 5 Phillip head screws to remove bowl cover. Picture 2 indicates where choke rod is connected (note index finger and thumb). Picture 3. The idle mixture screw will need to be adjusted in the counterclockwise direction several turns after engine is running to obtain satisfactory idle performance. Picture 2 also indicates location of the main metering jets, (in lower right of picture) shown also in Picture 4 which will need to be drilled out possibly as much as 40% larger. This should be done in progressive steps as some conditions, such as carbon deposits in the combustion chamber, engine size and carburetor application, may cause a need of a lesser enlargement. After the jet enlargement is done, care must be taken so as not to allow dirt or other foreign particles to fall into the carburetor fuel bowl. The cover now may be replaced. Be sure that the identification tag is put back on the carburetor. This operation can be done without removing the carburetor from the engine, provided care is exercised to prevent anything from being lost, especially down the venturi into the intake manifold.

Picture 3

Picture 4

Picture 5

Picture 6

Pictures 6 through 10 show a single barrel Autolite carburetor, commonly used on a 6-cylinder Ford engine. Again, Picture 6 shows the cover screws. Picture 7 is pointing out the main metering jet (left side of picture), while Picture 8 is telling you to be careful, don't lose these check balls. Picture 9 is indicating the jet and drill bit while Picture 10 indicates the idle mixture screw which will need to be backed out as needed for proper adjustment.

Picture 7

Picture 8

Picture 9

Picture 10

Picture 11

Picture 12

Pictures 11 through 14 indicate a single barrel Holley carburetor, used mainly on 6-cylinder Ford engines. Picture 11 indicates the 8 Phillip screws to remove in order to remove the cover. Picture 12 indicates the main metering jet location which Picture 13 shows to be drilled. Also, Picture 13 indicates the idle mixture screw which is located at the end of the screwdriver. It will need to be backed out several turns. Picture 14 is pointing to a check valve you must be careful not to lose. Reverse the disassembly procedure to reassemble.

Picture 13

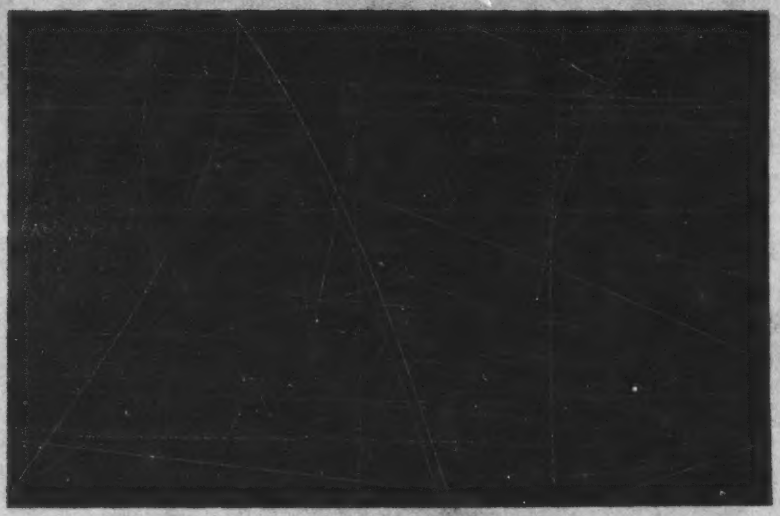
Picture 14

Pictures 15 through 19 show a single barrel Rochester carburetor, commonly used on G.M. 6-cylinder engines. This carburetor disassembly and assembly procedure is similar to the previous carburetors in that Picture 15 shows the cover screws, Pictures 16 and 17 show the main jet, while Picture 18 is showing the various vacuum nipples. Care must be taken to label the hoses before removing from the nipples so as to insure correct replacement, and Picture 19 is indicating the idle mixture screw.

Picture 15

Picture 16

Picture 17

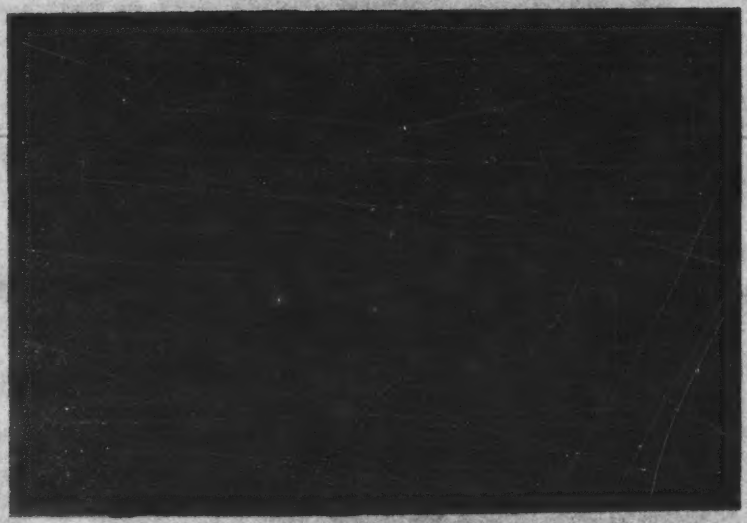


Picture 18

Picture 19

Pictures 20 through 24 indicate a two-barrel Rochester carburetor, used on a great many G.M. V-8 engines. Picture 20 shows the cover screws, Picture 21 indicates a choke rod, that will need to be disconnected in order to remove the cover. Notice Picture 22 indicates two main metering jets. They are identical and should be resized equally as Picture 23 indicates. Picture 24 indicates the two idle mixture screws. Generally they will be backed out an equal amount.

Picture 20

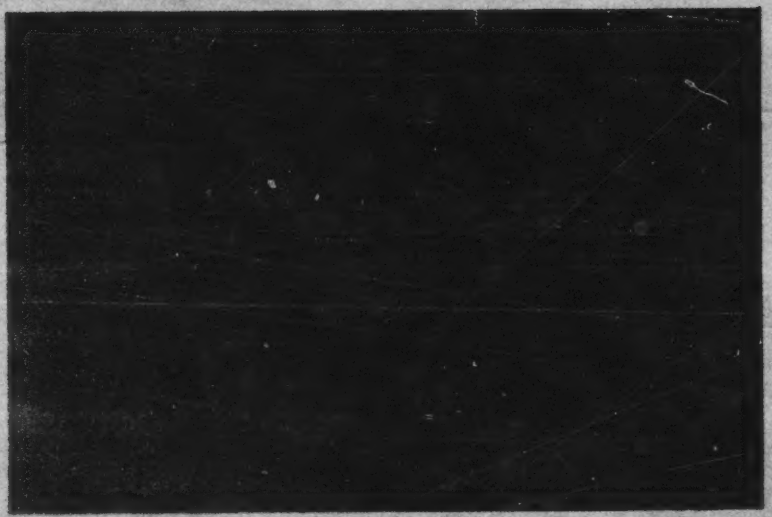


Picture 21

Picture 22

Picture 23

Picture 24



Pictures 25 through 31 show a two-barrel Ford carburetor, which is used on the majority of Ford 8-cylinder engines. In Picture 25 you will note that it will be necessary to remove the air cleaner stud, as well as the screws, in order to remove the cover. Picture 26 shows a choke linkage rod that on some carburetors will need to be removed; on others the rod has a nylon swivel and need not be removed. Picture 27 indicates on this carburetor it will be necessary to remove the float and fuel inlet needle by prying the wire bail out of its locking notch. By lifting the float out, the main metering jets are now exposed (Picture 28) and ready to be resized as shown in Picture 29. Picture 30 indicates reinstalling the float and carefully locking the float bail in its lock groove. Picture 31 indicates the two idle mixture screws, which will need to be backed out as necessary to obtain an acceptable idle.

Picture 25

Picture 26

Picture 27

Picture 28

Picture 29

Picture 30

Pictures 32 through 39 indicate the procedure to expose the metering rods and jets of a 4-barrel Rochester quadrajet. This carburetor is used by G.M. as a high performance carburetor option on all of their 8-cylinder engines. It is a bit more complex and modification of it should not be attempted unless you have 30% to 40% smaller metering rods on hand to replace the original rods with. Or you can, as an alternate method, drill the rod jets out as on previous carburetors I have discussed. Picture 32 shows the choke screw you must remove. Picture 33 indicates the necessity of removing the choke vacuum brake and Picture 34 shows two hidden screws before going on to the screws shown in Picture 35. Picture 36 indicates the linkage rod, which will need to be dealt with. Picture 37 indicates the jets and Picture 38 points out the metering rods, which have been mentioned earlier. Picture 39 indicates the idle screws.

Note the idle screws should first be backed out to attempt to achieve the correct idle, but this is impossible to achieve on some engines. Thus, it will be necessary to drill this orfice larger to be able to achieve a satisfactory idle mixture.

Picture 31

Picture 32

Picture 33

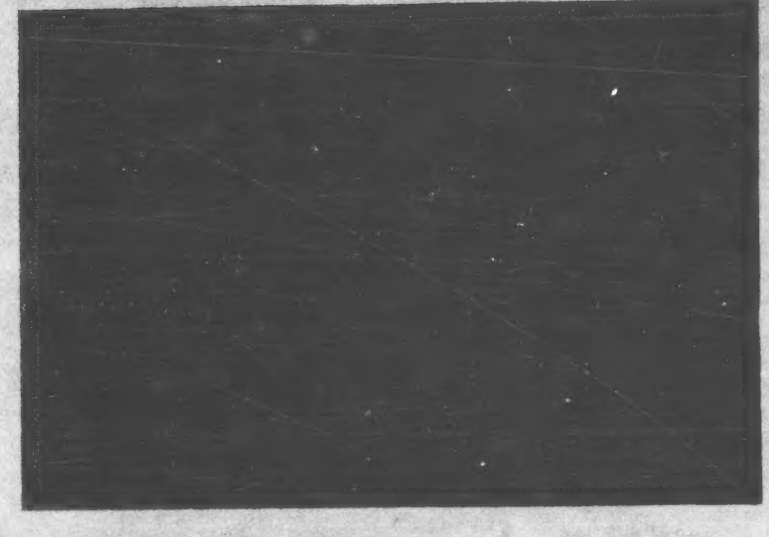
Picture 34

Picture 35

Picture 36

Picture 37

Picture 38



Picture 39

TOPIC C: Equipment Required for Demonstration and Further Testing of Alternate Fuels

1. Demonstration Carburetors

   A. 2 barrel Holley #5200
   B. 1 barrel Autolite
   C. 1 barrel Holley
   D. 1 barrel Rochester
   E. 2 barrel Rochester
   F. 2 barrel Ford
   G. 4 barrel Rochester Quadrajet

2. 26 Number Drills

   A. From #65 (.035) to #40 (.098)

3. Drill holder or mechanics vise

4. 7 medium size standard screwdrivers

5. 7 #2 Phillips screwdrivers

6. 7 needlenose pliers

7. 2 half inch combination wrenches

8. Visual aids of carburetion principles

9. Visual aids projection equipment

10. Optional: carburetion textbooks

11. Stationary engine equipped with modified carburetor

12. Engine dynometer

13. Vehicle suitable for road testing

14. Mileage tester for road test

15. Sufficient quantity of ethanol alcohol for testing purposes

16. Classroom suitable for size of group

17. Shop suitably equipped with benches for size group

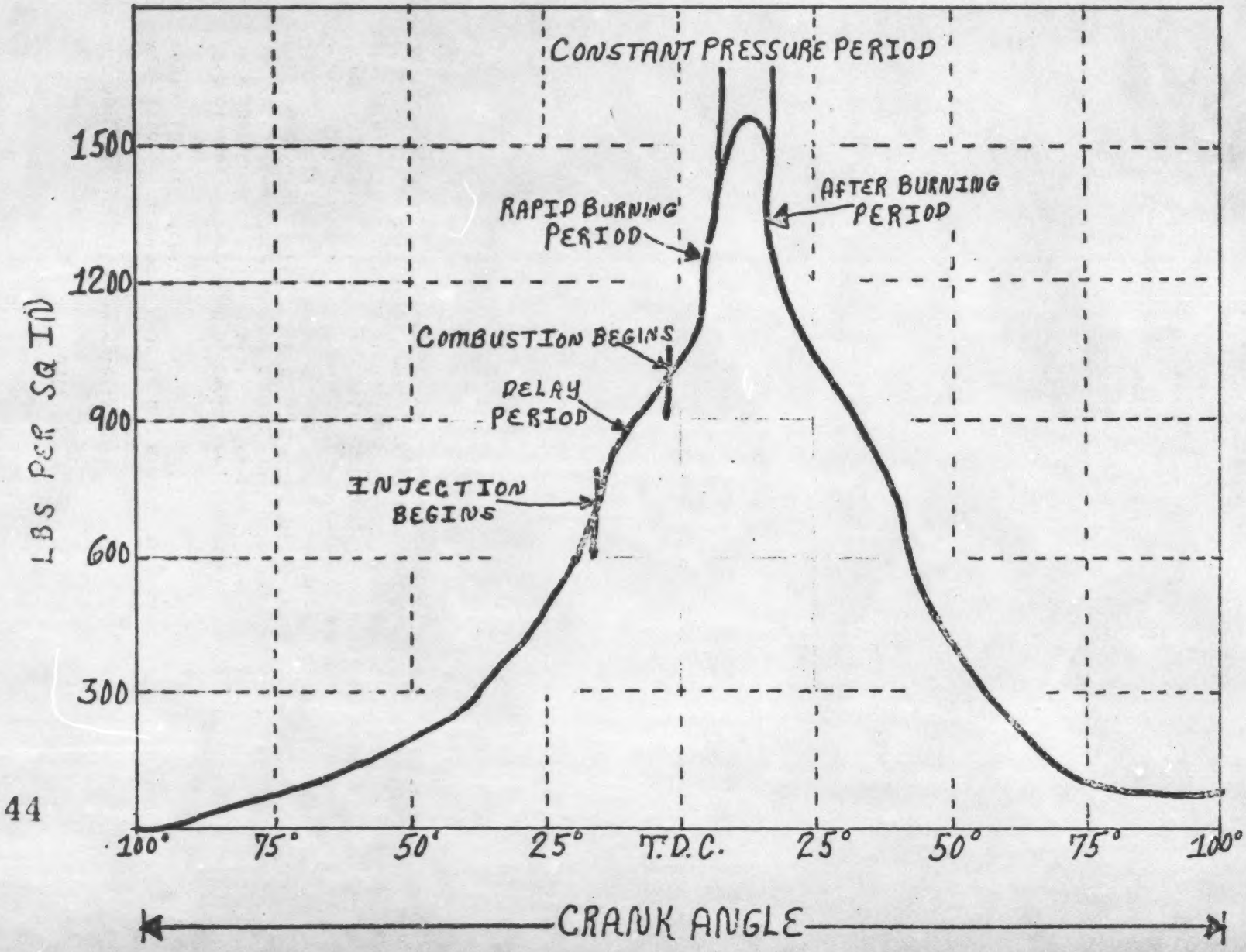
UNIT IV

TOPIC A: Alcohol Self Ignition Characteristics

Many attempts have been made to use alcohol as a compression ignition engine (diesel) fuel.

Alcohol fuel is very good as smokefree combustion results, but it has very poor self ignition qualities. As the "Burning the Fuel" chart indicates, the diesel engine has an ignition delay period before combustion actually takes place resulting in diesel knock. This is because it takes time to reach a self ignition temperature even with a diesel fuel with good ignition qualities (Cetane number 50+). Therefore considering Ethanol with a cetane number of approximately 8, something must be used as an igniter. In our test engine, we have used the diesel fuel as an igniter and introduced the alcohol to the engine cylinder by an alternate route which is the intake manifold air flow.

BURNING THE FUEL



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TOPIC B: Burning the Fuel Chart and Explanation of the Six Stages of Diesel Combustion

Six stages as per chart on previous page:

Stage 1. Injection begins - Diesel fuel begins to enter combustion chamber.

Stage 2. Delay Period - Ignition delay period between beginning of injection and beginning of combustion as fuel must reach a self ignition temperature. The length of this period is dependent upon several factors of which a very important one is self ignition quality (cetane) of the fuel.

Stage 3. Combustion begins - Some of the fuel just starts to burn.

Stage 4. Rapid Burning Period - During this time the fuel injected during the delay period and the fuel being injected during this period will burn and pressure and temperature will increase rapidly. Diesel knock is directly related to the amount of fuel accumulated during the delay period.

Stage 5. Constant Pressure Period - Fuel burns as it is injected during this period and injection usually ends just prior to the end of this period.

Stage 6. After Burning Period - During this period piston is rapidly traveling downward. The remaining fuel will finally vaporize, mix with oxygen if time permits and burn. (Refer to Diesel Fuels Search for Oxygen)

TOPIC C: Diesel Fuels Search For Oxygen

Air only is compressed in a diesel engine,so much higher compression is possible as fuel is not present, pre-ignition is no problem. More power is possible in an internal combustion engine with higher compression pressures as there is an approximate ratio of 1 to 4 of compression pressure to combustion pressure. Some added power is used of course, to produce the higher compression.

With this type of engine there is no pre-mixing of fuel and air before the combustion chamber, so the time of mixing the two is very short, therefore turbulance is the key to efficient compression ignition (diesel) combustion. As long as the rushing fuel particles meet fresh supplies of oxygen, the burning continues. The motion through the air removes the burned gases and exposes an ever-fresh surface of the fuel to the oxygen until the particle is completely consumed. But, the oxygen supply in the cylinder is definitely limited and each succeeding particle of diesel fuel finds an atmospher weaker in oxygen than did the fuel at the beginning of the power event. Those arriving near the end of the process find considerable difficulty in searching out the oxygen needed for rapid and complete combustion. Thus the process tends to slow up during the later stages, and the less complete combustion reduces engine power and efficiency.

Ethanol alcohol is composed of 3 elements; carbon, hydrogen and oxygen. Gasoline, diesel fuel and other petroleum distillates do not contain oxygen in their chemical structure. Therefore the oxygen in the alcohol is available for combustion, which lends to more complete utilization of the diesel fuel.

TOPIC D: Injection Pump To Engine Timing

Using an opposed plunger internal cam type fuel injection pump requires a timing change whenever the maximum fuel delivery specifications are altered.

An inherent characteristic of the pump is the retardation of injection timing as fuel delivery is decreased. This is caused by the fact that during less than maximum fuel operation the plungers move out only part way, and the start of injection takes place some what later in the pump cycle since the rollers, which actuate the pumping plungers, contact the lobes of the cam further up the cam ramp.

As it is not possible to time this pump by the flow timing method it must be air or pressure fuel timed and then timed to the engine according to maximum delivery specifications which the owner has decided upon.

TOPIC E: Alcohol Fuel Introduction to Engine

Fuel and air are not premixed. Air only is taken into the cylinders through a wide-open intake manifold and highly compressed. A correct amount of fuel is instantaneously sprayed into the hot, highly compressed air at exactly the right moment. Engine speed and power are controlled by regulating the quantity of fuel injected. There is no butterfly valve-type throttle plate in the intake system. Air intake is wide open at all times, therefore the diesel engine has relatively no intake vacuum as long as air intake flow is not restricted.

To use alcohol in a diesel engine a turbo charged engine was selected and we used intake manifold pressure from the turbo charger to pressurize an air tight tank containing alcohol. Therefore, alcohol is forced in to the intake side of the turbo charger through a shut off valve and carburetor metering jet to mix with the incoming air to the cylinders. As an alternate means of introducing alcohol to the diesel engine, an electric fuel pump in the alcohol fuel supply line was used and then instead of pressurizing the tank, have now vented it. The electric fuel pump must have sufficient pressure to overcome turbo pressure and be compatible with alcohol fuel.

TOPIC F: Diesel & Alcohol -- Test Results

ENGINE - 6-354-T Perkins

With CAV-DPA Fuel Injection Pump calibrated on the test bench to specifications of 63 MM 3/stroke and high idle adjusted to 2700 RPM tests were run on 100% diesel fuel at rated load speed of 2350 RPM on dynamometer and 410 PSI on gauge resulting in 95 HP. Fuel injection pump was then recalibrated to deliver 30% less fuel or 44.1 MM 3/stroke. With 30% less fuel and high idle at 2700 RPM (same) the engine now delivered 225 PSI resulting in 63 HP. At this time the alcohol valve was opened and allowed to enter the engine until 410 PSI at 2350 RPM was reached which was the original test result with 100% diesel fuel.

High Idle 2700 RPM

Rated Load 2350 RPM

PSI Scale - 410

BHP - 95

Fuel 100% Diesel Fuel

Fuel Injection Pump - 63 MM 3/stroke

Exhaust Temperature - 1000 F

ALCOHOL INTRODUCED BEFORE TURBO

High Idle - 2700

Rated Load - 2350

PSI Scale - 410

BHP - 95

Fuel - 70% Diesel - 30% 190 Proof Alcohol

Fuel Injection Pump - 44.1 MM 3/Stroke

Exhaust Temperature - 920 F

High Idle - 2700

Rated Load - 2350 RPM

PSI Scale - 225

BHP - 63

Fuel - 100% Diesel Fuel

Fuel Injection Pump - 44.1 MM 3/Stroke

Exhaust Temperature - 925 F.

ALCOHOL INTRODUCED AFTER TURBO

High Idle - 2700 RPM

Rated Load - 2350

PSI Scale - 410

BHP - 95

Fuel - 70% Diesel - 30% 190 Proof Alcohol

Fuel Injection Pump - 44.1 MM 3/Stroke

Exhaust Temperature - 920 F.

TOPIC G: Diesel & Alcohol -- Test Results

ENGINE - 310 WAUKASHA

With Roosa Master Fuel Injection Pump calibrated on the test bech to specifications of 72 MM 3/Stroke and high idle adjusted to 2652 RPM tests were run on 100% diesel fuel at rated load speed of 2400 RPM on dynamometer and 510 PSI on guage resulting in 114 HP. Fuel injection pump was then recalibrated to deliver 25% less fuel or 54 MM 3/Stroke. With 25% less fuel and high idle at 2652 (same) the engine now delivered 370 PSI resulting in 90 HP. At this time the alcohol valve was opened and allowed to enter the engine until 510 PSI at 2400 RPM was reached which was the original test result with 100% diesel fuel.

High Idle - 2652 RPM

Rated Load - 2400 RPM

PSI Scale - 510

BHP - 114

Fuel - 100% Diesel Fuel

Fuel Injection Pump - 72 MM^3 /Stroke

High Idle - 2652 RPM

Rated Load - 2400 RPM

PSI Scale - 370

BHP - 90

Fuel - 100% Diesel Fuel

Fuel Injection Pump - 54 MM^3 / Stroke

* Exhaust Temperature - 1475 F.

High Idle - 2652 RPM

Rated Load - 2400 RPM

PSI Scale - 510

BHP - 114

Fuel - 75% Diesel Fuel
25% 160 Proof Alcohol

Fuel Injection Pump - 54 MM^3 /Stroke

* Exhaust Temperature - 1250 F.

TOPIC G, Continued: Diesel & Alcohol Test Results

High Idle - 2652 RPM	High Idle - 2652 RPM
Rated Load - 2400 RPM	Rated Load - 2400 RPM
PSI Scale - 290	PSI Scale - 210
BHP - 77 --- 114	BHP - 50 --- 114
Fuel - 60% Diesel Fuel 40% 160 Proof Alcohol	Fuel - 50% Diesel Fuel 50% 160 Proof Alcohol
Fuel Injection Pump - 43 MM^3 /Stroke	Fuel Injection Pump - 36 MM^3 /Stroke
* Exhaust Temperature - 1250 F.	* Exhaust Temperature - 1240 F.

Tests with less percentage of diesel fuel were not possible as fuel injection pump would not deliver fuel at cranking speed when adjusted to any lower specifications.

Flow meters have not arrived yet to give actual GPH of diesel fuel and alcohol with the above tests. The Diesel Fuel percentages will remain the same as fuel injection pump is not permitted to deliver any more fuel even though the governor calls for an increase.

Water Temperature is high due to inadequate size cooling system.

* Exhaust temperature is high as cooling capacity is limited and building exhaust system has a certain amount of back pressure. The exhaust temperature in every test is lower with alcohol being used than with 100% diesel fuel.

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TOPIC C: Glossary of Alcohol Related and Automotive Terms

accelerator pump--A single-stroke mechanical pump, activated by depressing the accelerator pedal, which injects a small stream of additional fuel down the throat of the carburetor to enrich the air/fuel ratio during acceleration.

aeration--When a liquid is charged with a gas (or air), some of the gas is dissolved in the liquid. This is the free gas in the solution and is available to the organisms(such as fish or, in our case, yeast and bacteria)that live in the solution.

air cleaner--A device for filtering, cleaning and removing dust from intake air to and engine, air compressor, etc.

ambient--Surrounding on all sides.

API--American Petroleum Institute.

ASIA--Automotive Service Industry Association.

ASME--American Society of Mechanical Engineers.

atmospheric pressure--Weight of air at sea level, about 14.7 psi.

azeotrope(also known as azeotropic mixture)--When two miscible components are distilled, and they do not change ratio of composition, they are known as an azeotropic mixture. For example, ethyl alcohol and water form an azeotrope when the alcohol and water percentages are 95.6% and 4.4% respectively. At this point simple distillation will not remove the water from the alcohol. This is why 200-proof ethyl alcohol cannot be achieved by simple distillation. To break this azeotrope, a third chemical must be added to the composition to form a tertiary azeotrope. When benzene is added to the alcohol/water azeotrope and the resulting mixture is distilled, the tertiary azeotrope distills off the top of the column, leaving behind anhydrous ethyl alcohol.

backfire--Ignition of mixture in intake manifold by flame from a cylinder.

BDC--Bottom dead center.

BHP--Brake horsepower is a measurement of power developed by an engine in actual operation.

boiling point--Temperature at atmospheric pressure at which bubbles or vapors rise to surface and escape.

brake horsepower--Actual horsepower delivered by crankshaft, measured by means of a dynamometer or prony brake.

butane--A petroleum hydrocarbon compound which has a boiling point of about 32 deg. F, which is used as engine fuel. Loosely referred to as Liquefied Petroleum Gas and often combined with Propane.

calorific value--A measure of heating value of fuel.

calorimeter--An instrument to measure amount of heat given off by a substance when burned.

calory--Metric measurement of amount of heat required to raise 1 gram of water from zero deg. to 1 deg. Celsius.

carbon--A common, nonmetallic element that is an excellent conductor of electricity. It also forms in combustion chamber of an engine during burning of fuel and lubricating oil.

carbon dioxide--Compressed into solid form, this material is known as "dry ice" and remains at a temperature of -109 deg. F. It goes directly from a solid to a vapor state.

carbon monoxide--Gas formed by incomplete combustion. Colorless, odorless, poisonous.

carbonize--Process of carbon formation within an engine. Examples: deposits on spark plugs and within combustion chamber.

carburetor--A device for automatically mixing fuel in proper proportion with air to produce a combustible gas.

carburetor "icing"--A term used to describe formation of ice on a carburetor throttle plate during certain atmospheric conditions.

catalytic converter--Emission control device in exhaust stream that chemically treats exhaust gases after combustion to oxidize noxious emissions.

celsius--A scale of temperature measurement on which, under standard atmospheric pressure, water freezes at 0 deg. and boils at 100 deg.

choke--A reduced passage. Example: valve in carburetor air inlet to cut down volume of air admitted.

"cold" manifold--An intake manifold not heated by exhaust gas.

combustion--Process of burning.

combustion chamber--Volume of cylinder above piston with piston on top center.

compression ratio--Volume of cylinder and combustion chamber with piston at bottom center as compared with volume of chamber at end of compression stroke.

connecting rod--Rod that connects piston to crankshaft.

coolant--Liquid circulated through cooling system of a "water-cooled" engine, usually a mixture of about 50 percent ethylene glycol and 50 percent water.

crankcase dilution--Under certain conditions of operation, unburned portions of fuel get past piston rings into crankcase where they "thin" engine lubricating oil.

crankshaft--Main shaft of an engine which, in conjunction with connecting rods, changes reciprocating motion of pistons into rotary motion.

cylinder--A round hole having some depth bored to receive a piston. Also referred to as "bore."

cylinder block--Largest single part of an engine. Basic or main mass of metal in which cylinders are bored or placed.

cylinder head--A detachable portion of an engine fastened securely to cylinder block which contains all or a portion of combustion chamber.

cylinder head gasket--Seal between engine block and cylinder head.

dead center--Extreme upper or lower position of crankshaft throw at which point piston is not moving in either direction.

denatured alcohol--Ethyl alcohol to which a denaturant has been added.

detergent--A compound of a soap-like nature used in engine oil to remove engine deposits and hold them in suspension in oil.

detonation--Also referred to as pre-ignition or "knock", this undesirable situation comes about when the air/fuel mixture is ignited prematurely because of either too-advanced spark timing or use of a low grade of fuel which cannot tolerate the intense compression built up in the engine's combustion chamber.

dieseling--Engine tends to keep running after ignition key is turned off.

down-draft--Carburetor in which mixture flows downward to engine.

economizer--A device installed in a carburetor to control amount of fuel used under certain conditions.

EEC--Evaporative Emission Controls.

EGR--Exhaust Gas Recirculation.

ethyl gasoline--Gasoline to which a compound of tetraethyl lead, ethylene dibromide and ethylene dichloride has been added. Material slows down and controls rate of burning of fuel in cylinder to produce an expansive force rather than an explosive force to reduce detonation or "knocking" in an engine.

exhaust emissions--Products of combustion that are discharged through exhaust system of vehicle.

exhaust gas analyzer--An instrument for determining efficiency with which an engine is burning fuel. Also called combustion analyzer or emissions tester.

filter--A device designed to remove suspended impurities or particles of foreign matter from intake air, fuel system or lubricating system.

flash point--Temperature at which an oil will flash and burn.

float--A hollow part which is lighter than fuel or fluid in which it rests, and ordinarily used to operate a valve controlling entrance of fuel or fluid.

float level--Predetermined setting of float to control height of fuel in carburetor bowl, usually regulated by means of a suitable valve.

float valve--A check valve within the carburetor which shuts off the incoming supply of fuel to the carburetor float bowl when the correct level within the bowl is attained.

forged crankshaft--A high-strength crankshaft which is forged rather than cast in order to tolerate increased compression ratios without flexing.

four cycle engine--Engine in which an explosion occurs every other revolution of crankshaft. A cycle, also known as Otto cycle, is considered 1/2 revolution of crankshaft. Strokes are: suction, compression, power, exhaust.

heat exchanger--A device that utilizes exhaust system heat to aid in fuel vaporization.

heat of compression--To understand why knocking occurs, let us first see what happens to any gas when it is compressed. As an example, consider what happens to the temperature of air at atmospheric pressure when it is compressed adiabatically to one-fifteenth of its original volume(in an engine with a compression ratio of 15:1). When this happens, the temperature of the air rises more than 1,000 deg. F. When the air is compressed, work is done on it;this work is converted into heat energy, thus raising the temperature of the air. This temperature rise is called the heat of compression.

heat riser--Passage between exhaust and intake manifolds.

heat value--The heating value of a fuel is a measure of how much energy we can get from it on a per-unit basis, be it pounds or gallons. When comparing alcohol to gasoline using this "measuring stick", it's obvious that ethanol contains only about 63% of the energy that gasoline does...mainly because of the presence of oxygen in the alcohol's structure. But since alcohol undergoes different changes as it's vaporized and compressed in an engine, the outright heating value of the ethanol isn't as important when it's used as a motor fuel. The fact that there's oxygen in the alcohol's structure also means that this fuel will naturally be "leaner" in comparison to gasoline fuel...without making any changes to the jets in the carburetor. This is one reason why we must enrich the air/fuel mixture(add more fuel)when burning alcohol by increasing the size of the jets, which we'll discuss further in another section.

HEI--High Energy Ignition.

high-compression pistons--Forged aluminum pistons with domed, notched heads which increase the compression ratio in an engine and still allow clearance for valve lift.

hydrocarbon--Any compound composed entirely of carbon and hydrogen.

hydrocarbon engine--An engine using petroleum products, such as gas, liquefied gas, gasoline, kerosene or fuel oil as a fuel.

hygroscopic--Alcohol is hygroscopic. That means it can attract or absorb moisture from the air. This is why it is impossible to keep 200 proof alcohol in storage very long(even if you could produce it), as it would soon dilute itself with available airborne moisture. A 170 proof alcohol fuel will not attract very much moisture from the air, so storage is really no problem.

idle orifice--The passage through which the air/fuel mixture is controlled during engine idle. The size of this orifice is adjustable through the use of a tapered idle mixture screw.

ignition system--Means for igniting fuel in cylinders. Includes spark plugs, wiring, ignition distributor, ignition coil and source of electrical current supply.

IHP--Indicated horsepower developed by an engine and a measure of pressure of explosion within cylinder expressed in pounds per square inch.

injector--A pump which injects or inserts a fluid or gas, usually against pressure, into a cylinder or chamber.

intake manifold--The assembly of channels which delivers the air/fuel mixture from the carburetor to each cylinder.

intake valve--A valve which permits a fluid or gas to enter a chamber and seals against exit.

knock--Term used to describe various noises in an engine made by loose or worn mechanical parts, preignition, detonation, etc.

latent heat of vaporization--Latent heat of vaporization is the phenomenon that results in an alcohol-powered engine's running cooler than its gasoline-fueled counterpart. When a substance is about to undergo a change in form(from a liquid to a vapor, in this case), it must absorb a certain amount of additional heat from its surroundings in order for the change to take place. Since alcohol must absorb roughly 2-1/2 times the amount of heat that gasoline does, and the heat naturally is taken from the engine block the engine should operate at a much lower temperature...in theory, that is. What happens in reality is that the alcohol/air mixture doesn't have time to absorb all the heat it could during it short trip through the engine manifold. So instead of running 2-1/2 times cooler on alcohol than it does on gasoline, the engine operates at temperatures only slightly cooler--about 20-40 deg. F lower, depending on the specific engine--when using alcohol fuel.

liter--A measure of volume equal to 61.027 cu.in.

main bearings--Antifriction sleeves between the connecting rods and the crankshaft journals which provide for lubrication, expansion and and contraction, and extreme thrust pressures.

main metering jet--The fixed-size orifice (usually brass) which meters the correct amount of fuel from the float bowl to be mixed with air entering the air horn.

manometer--A device for measuring a vacuum, consisting of a "U" shaped tube partially filled with fluid. One end of tube is open to air, other is connected to chamber in which vacuum is to be measured. A column of mercury 30 in. high equals 14.7 psi, which is atmospheric pressure at sea level. Readings are given in inches of mercury (Hg).

methanol or wood alcohol--A poisonous alcohol made synthetically or from distillation of wool.

NOx--Nitrogen oxides.

octane--One component of gasoline which is used by the industry as a measurement of the fuel's ability to resist pre-ignition or engine knock. Octane is ahydrocarbon in gasoline.

octane number--A unit of measurement on a scale intended to indicate the tendency of a fuel to detonate or knock.

octane rating--Actually, when referring to alcohol fuels, the word "octane" does not apply, since octane is merely the hydrocarbon in gasoline which is assigned the numerical value of 100 for fuel-rating purposes. The octane number given automotive fuels is really an indication of the ability of the fuel to resist premature detonation within the combustion chamber. (Premature detonation, or engine knock, comes about when the fuel/air mixture ignites spontaneously toward the end of the compression stroke because of intense heat and pressure within the combustion chamber. Since the spark plug is supposed to ignite the mixture at a slightly later point in the engine cycle, pre-ignition is undesirable, and can actually damage or even ruin an engine.) Because a high compression ratio in an engine results in more power per stroke, greater efficientcy, and better economy, it's easy to see why a fuel that resists pre-ignition even under high compression conditions is especially desirable...and alcohol is, on the average, about 16 points higher on the research octane scale than premium gasoline.

orifice--Small opening in a tube, pipe or valve.

otto cycle--Four stroke cycle named after man who adopted principle of four stroke operation for each explosion in an engine cylinder. They are: suction, compression, power and exhaust.

thermactor--Ford air pump type exhaust emission control system.

thermal efficiency--A gallon of fuel contains potential energy in form of heat when burned in combustion chamber. Some heat is lost and some is converted into power. Thermal efficiency is ratio of work accomplished compared to total quantity of heat contained in fuel.

thermal reactor--Emission control device that accepts raw exhaust gases from engine and subjects them to extremely high temperatures to oxidize noxious emissions.

thermostat--A heat-controlled valve used in cooling system of engine to regulate flow of water between cylinder block and radiator. A thermostat is also used in modern air cleaners in which inlet air temperature is regulated.

turbocharger--An air pump, driven by the engine's escaping exhaust gases, which greatly compresses the fuel/air mixture in the intake manifold and hence the combustion chamber. The net effect is similar to that of a supercharger.

upper cylinder lubrication--A method of introducing a lubricant into fuel or intake manifold in order to permit lubrication of upper cylinder, valve guides,etc.

vaporizer--A device for transforming or helping to transform a liquid into a vapor.

vapor lock--A condition in which fuel boils in fuel system, forming bubbles which retard or stop flow of fuel to carburetor.

vapor pressure--Pressure developed over a liquid in a closed vessel, depending upon liquid and temperature.

venturi--Two tapering streamlined tubes joined at their small ends to reduce internal diameter.

volatility--The volatility of a fuel refers to its ability to be vaporized. This is an important factor, because if vaporization doesn't occur readily the fuel can't be evenly mixed with air and is of little value in an engine. Some substances that are highly volatile can't easily be used as a motor fuel...and others, which have excellent heating value, aren't volatile enough to be used in an engine (such as tars and waxes). Another point to keep in mind is that a very volatile fuel is potentially dangerous, because of the chance of explosion from heat or sparks. This is one reason why alcohol, with a higher flash point than gasoline, is a much safer automotive fuel...especially considering that the average car's storage tank is really quite vulnerable.

volumetric efficiency--A combination between ideal and actual efficiency of an internal combustion engine. If engine completely filled each cylinder on each induction stroke, volumetric efficiency of engine would be 100 percent. In actual operation, however, volumetric efficiency is lowered by inertia of the gases, friction between gases and manifolds, temperature of gases and pressure of air entering carburetor. Volumetric efficiency is ordinarily increased by use of large valves, ports and manifolds and can be further increases with aid of a supercharger.